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A Decision Support System for Farm Mechanization with the Use of Computer Modeling For Soybean-Wheat Crop Rotation

Abhay Kumar Sinha, Atul Kumar Shrivastava, Avinash Kumar Gautam and Shahid Ahamad*

Department of Farm Machinery and Power Engineering
College of Agricultural Engineering, JNKVV, Jabalpur (M.P.)
*Krishi Vigyan Kendra,Reasi ,SKUAST-Jammu
Email: abhaysinha.1995@gmail.com

Abstract:

The selection of tractor and its matching implements has now become very difficult in Mahakoshal region as well as in Madhya Pradesh because of availability of variety of tractor models ranging from 10 kW to 80 kW. Selection of proper size of farm power and machinery is the most important component of any farm enterprise. Among the various inputs to the crop production system, power and machinery jointly represent the largest single item of expenditure constituting about 60% of the total investment on the farm. The decision on optimum size of machinery is quite critical not only because of the high proportion of total cost attributed to machinery but also due to the infrequency and irrevocability of such decisions. To overcome the problem of matching of tractor - implement system, an expert system modeling approach leading to decision support system (DSS) was adopted to make the step wise decision. The DSS leading to computer software developed in Visual Basic Programming provided the intuitive user interface by linking databases such as area under the crop, soil type, number of operations for each crop and time available for each operations. The programme calculates working width of implement based on input data for the most critical field operation and helps in selection of a suitable implement having width nearer to the calculated value among the commercially available implements. The software also calculates the optimum tractor size from amongst the available sizes based on draft and working speed of the selected implement. Chi-square test revealed that there was no significant difference between the actual size of farm power owned by the farmers of the study area and the prediction of the model. Thus, the model predictions are good for soybean-wheat cropping system of the study area and can be used successfully for selection of optimal power and machinery.

Keywords: Decision support system, power machinery,cropping system.

1.Introduction

The level, appropriate choice and subsequent proper use of mechanized input into agriculture has a direct and significant effect on achievable levels of agricultural production, the profitability of farming and the environment. Introduction of farm machine enables timely operations resulting in increased production besides the reduced drudgery. Despite its high cost and high profile, mechanization is still only an input like any other such as seed, fertilizer and crop protection chemicals, and is one of a mix of management tools a farmers has available to maximize production and profit. Selection of proper size of farm power and machinery is the most important component of any farm enterprise. The size or capacity and number of equipment should match the power required by the various sequences of cropping operations that must be performed within specified time periods with the minimum cost. Over sizing the power sources or the machinery, help of reduce the labour cost as well as timeliness costs. However, this benefit may be offset by higher fixed cost as available as it's for specific land holding size. Selection and use of under sized implements on the other hand, may result in higher labour and timeless cost, thereby, ultimately reducing the net returns. The decision on optimum size of machinery is quite critical not only because of the high proportion of total cost attributed to machinery but also due to the infrequency and irrevocability of such decision

Several models have been developed to simulate field machinery selection such as Sahu and Raheman (2008) and Dubey (2010). Selection criteria in those models are based on a economic analysis Camarena *et al.* (2004), timeliness of operation Sogaard and Sorensen (2004) and least cost technique Dash *et al.* (2008) and Naik (2011). Most of these models are suitable for use of the research workers for a particular cropping system.

A few location specific studies have been conducted in India for the selection of power and machinery for different farm sizes. However, no information is

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available for the selection of machinery for soybean-wheat cropping system, an important cropping system of many part of country as well as Mahakoshal region of Madhya Pradesh occupying an area of 806.70 thousand hectare of soybean crop and 874.70 thousand hectare of wheat crop. In this cropping system, farmers, generally, do not have sufficient time for field preparation and sowing of wheat Brown and Schoney (2008).Keeping these points in view, the main objective of this present study was to develop a user friendly computer model based on the least cost technique for selection of optimum size of power and machinery for soybean-wheat cropping system.

2. Theoretical consideration

2.1 Power requirement of a tractor

The power requirement of a tractor for different field operations can be calculated after getting the preliminary details regarding land holding, total available working time, soil conditions and type of operations .Therefore, it is recommended that the field operation which is the most time sensitive or that require the highest power should be taken into consideration for determining the power of a tractor. Cost of operation with different size group of tractors are different. For the cost analysis the information were collected related with price per unit size or capacity, economic life, repair and maintenance cost over the life of the equipment as a fraction of purchase price, sale tax, salvage value factor, interest, insurance rate and shelter cost of equipment. Price of oil, fuel, labour cost, tractor operator cost and working hour per day were also required by the model. The appropriate selection of these components is important for determining the profitability of the given farming system.

2.2. Selection of optimum size of tractor

The optimum size of tractor is considered to be one, which will perform all the desired operations at minimum cost.

Optimum rated power, KW

$$(\mathrm{Pr})optimum = \left[\sum \left(\frac{100 A_i D_i n_i}{(Fc\%)(Ppt)(r)} \times \left(L + \frac{K_i Y_i V_i A_i}{(Sc)_i (Nt)_i U_i h_i} \right) \right) + \sum \left(\frac{100 \times 0.27 \times D_i W_i Lt}{(Fc\%)(Pt)(r)} \right) \right]^{1/2} \quad \ldots(1)$$

A suitable load factor of 0.75 was considered for recommended power and

$$\text{Recommended power} = \frac{(Pr)\ \text{optimum}}{0.75}$$

Where,

i = Subscript identifying specific operations, area, energy values, labour costs, etc.;

A = Area under crop,ha;

n = Number of passes of implement;

K = Timeliness loss factor per day;

Fc% = value of fixed cost percentage of tractor;

Y = Expected yield of crop,q/ha;

V = Value of crop, □/q;

r = Ratio of draw bar power to axle power;

Sc = 2 for premature or delayed schedules, 4 for balance schedules.;

Nt = Number of times area should be divided because of dispersed optimum times;

h = Actual number of hours utilized;

U = Fractional utilization of total times, decimal;

L = Tractor operator's wages for field work, □/h;

D = Distance to be covered, km;

W = Weight to be carried, tonnes;

Lt = Labour cost for transportations, □/ha and

Ppt = Price per unit power of tractor

2.3. Selection of optimum width of machine

For field machinery selection, the most pertinent variable is size or capacity of the machine. Although forward speed and power availability affect capacity, initially it is assumed that power is not lacking and the forward speed is the maximum value does not reduce the effectiveness of operation.

$$W = \left\{ \frac{100 \times C \times A}{(Fc\%) \times P \times S \times e} \left[L + T + \frac{K \times Y \times V \times A}{(Sc)\ (Nt) \times U \times h} \right] \right\}^{1/2} \quad \dots(2)$$

Where,

W = optimum width of machine, m;

Fc% = fixed cost percentage of implement price;

P = Purchase price of the implement, □;

C = Constant i.e. 10;

A = Area under the implement, ha;

S = Speed of implement, km/h;

e = Field efficiency of implement;

L = Labour charges, □/h;

T = Tractor operating cost, □/h.

3. Development of power selection model

A decision support system (DSS) was developed for selection of tractor and its matching equipment and vice versa for different soils and operating conditions as shown in Fig. 1 and Fig. 2. It was developed using Visual Basic 6.0 as front end and Micro-soft Access as back end. There were several sequential screens to complete the process and get the desired output. The developed screens were very intuitive and easy to select the parameters and enter the required values wherever required.

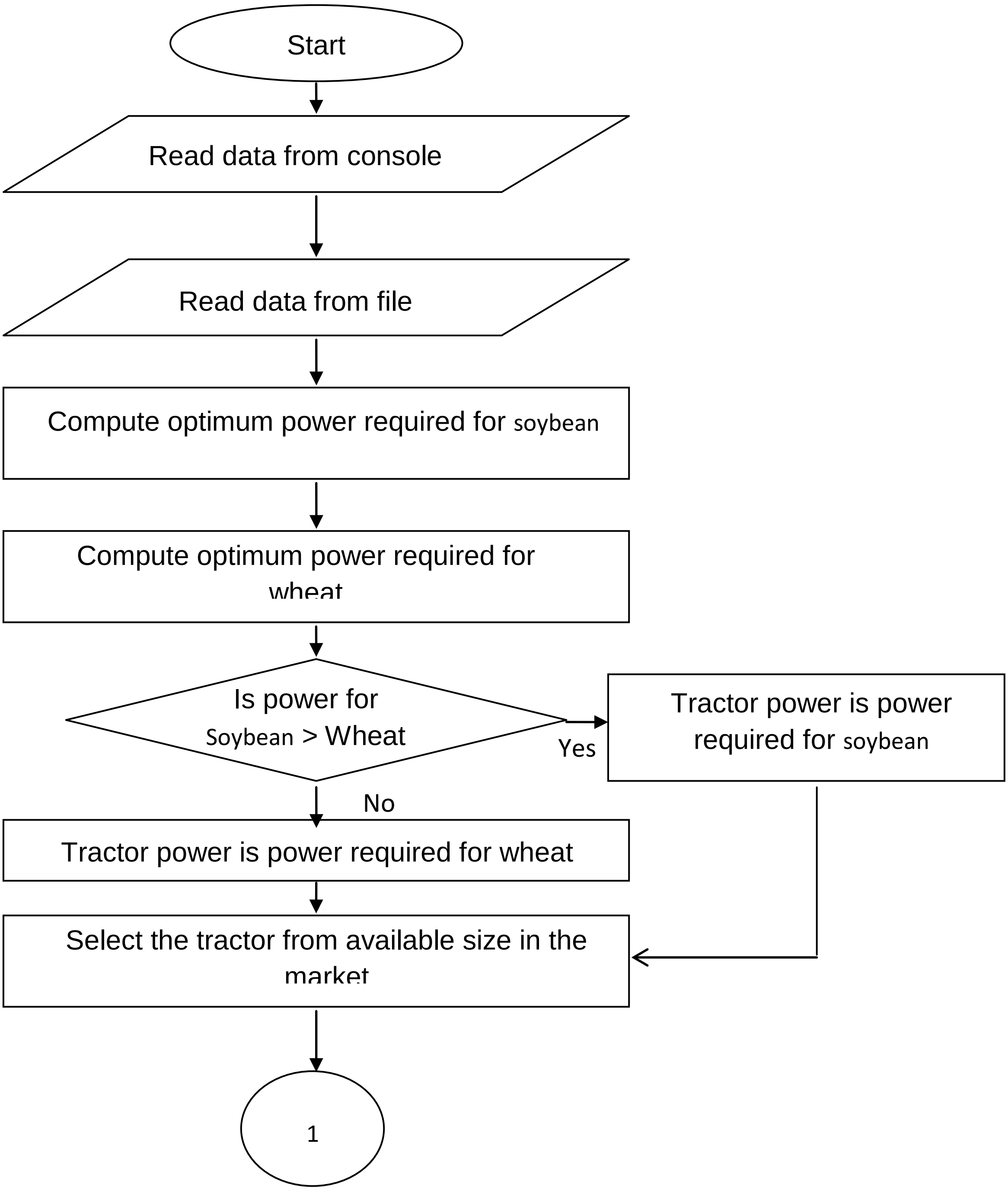

Fig 1. Flow chart for computer program for optimum selection of tractor

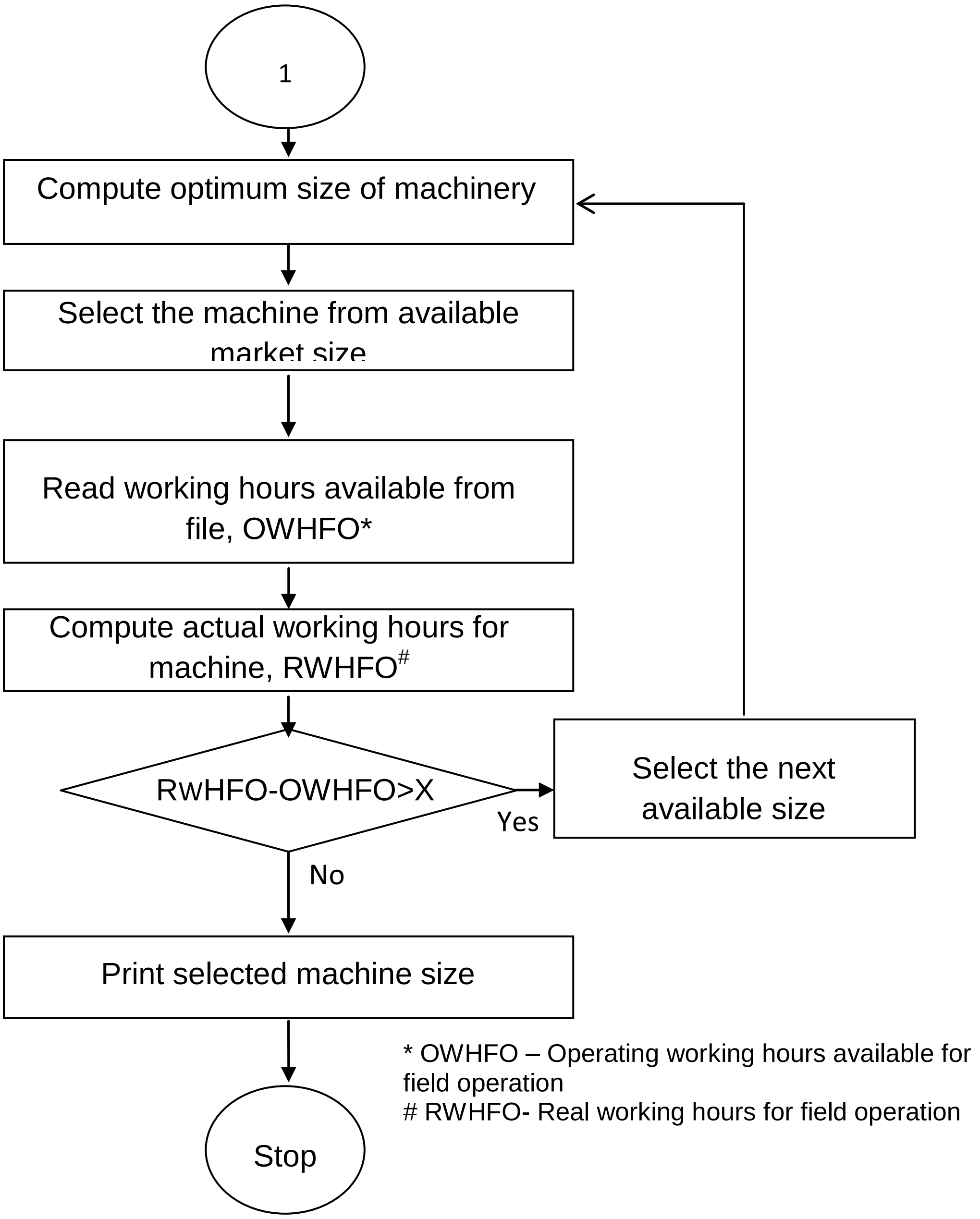

Fig .2.Flow chart for computer program for optimum selection of farm equipment

3.1 Selection of tractor

Power of tractor was selected in terms of tractor PTO power as per given farm size. It was selected as per the commercially available power rating of different models of tractor available in the market. The minimum size of the tractor available in the local market was 16.20 KW and was selected, by default option, for the minimum area of 1 ha even though the power requirement was much less i.e. 10.48 KW only. The limitations of market availability of tractor imposed restriction on the selection of exact and required power rating of tractor for a given farm size.

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Consequently, one particular power rating of tractor was selected for a certain clusters of farm sizes. Beyond 23 ha of farm size, a single tractor of 70.38 KW was not adequate to meet the power demand. Since, tractor above 70.38 KW, PTO power is not available in local market, therefore the programme suggest for two tractor of required capacity, which can do the work faster or say within the time, and also given the breakeven point of two tractor cost is earlier than instead of purchasing one more KW tractor.

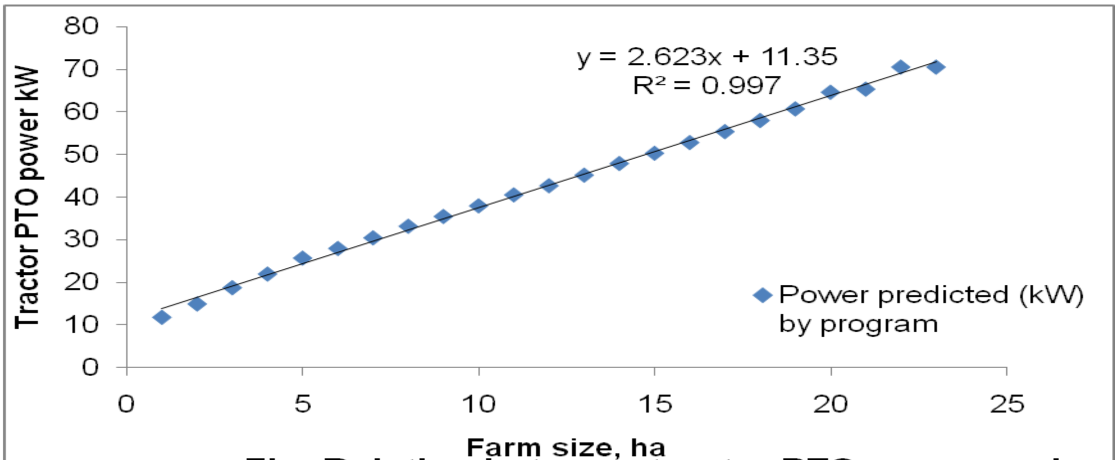

Fig. Relation between tractor PTO power and farm size

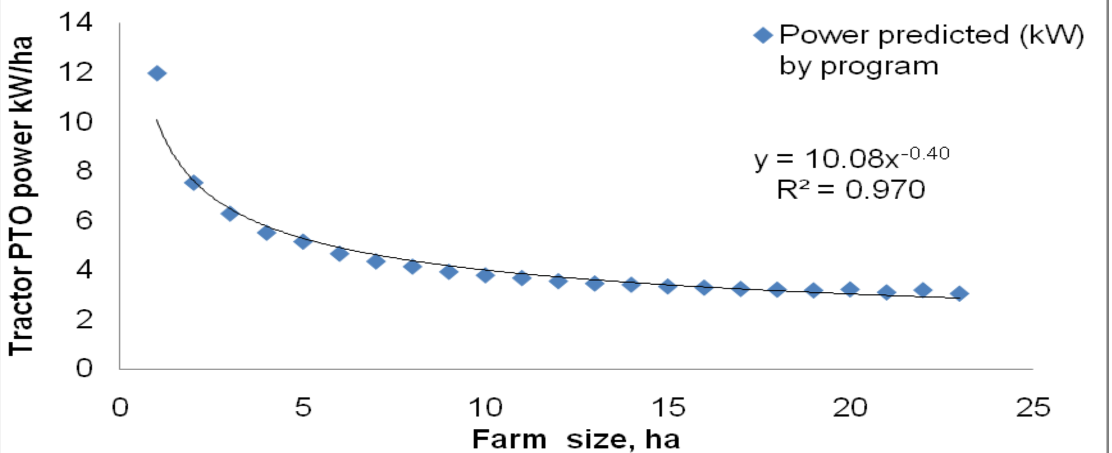

Fig. Relation between unit tractor PTO power and farm size

The model a linear relationship was found between the optimum PTO power of tractor selected and the farm size as shown in Fig. 3. The unit power requirements for different farm sizes were also computed and are shown in Fig.4. The unit power requirement followed an inverse relationship with the farm size. Initially it decreased rapidly from 1 to 3 ha of farm size, and thereafter, it tended to be asymptotic with the farm size.

This observation was in agreement with the opinion of the other researchers finding such as Hetz and Esmay (1986); Isik and Sabanci (1993) and Vasta and Saraswat (2008).

The maximum tractor PTO power required for 1 ha farm size was 11.97 KW/ha. Whereas, it was found minimum 3.07 KW/ha for 23 ha farm size. Although the selected PTO power 2.61 KW/ha was found to be at par for between 13-14 ha farm size.

3.2 Selection of machinery size

The developed model were used to find out different matching machineries for the tractor power as well as the machinery capacity to complete the operation in the scheduled time. For deciding the size of machinery, power match with tractor was given higher preference than the capacity match of the equipment to complete the operation in time.

It was observed that size of the machinery increased with increase in farm sizes (Table 1). A single bottom 30 cm mould board plough and Disc plough was selected for farm sizes up to 5 ha, which was the minimum size of the plough available in the market. Beyond 8 ha farm, a three bottom 30 cm plough was selected, which was the largest plough available in the market of Madhya Pradesh.

The minimum 7-tyne cultivator of size 1.5 m was selected for farm sizes up to 9 ha, which was able to complete the field operations within the specified time. It was observed that 9-tyne cultivator (1.96 m) was adequate for 10, 11 and 12 ha farms and from 13 ha to 19 ha farms 11-tyne cultivator (2.41 m) was selected .Beyond 19ha farm, 13-tyne cultivator (2.83 m) which was the maximum available size in the market.

Table 1. Selection of size of machinery set by the model FMOS

Farm size (ha)	Size of the matching equipment selected by the programme (FMOS)							
	MB plough, m	Cultivator, m	Disc harrow, m	Rotavator, m	Disc plough, m	Seed drill, m	VCR, m	Thres-her, t/h
1.00-4.00	0.30	1.50	1.25	1.25	0.30	1.80	2.20	0.50
5.00	0.30	1.50	1.25	1.25	0.30	1.80	2.20	0.60

6.00	0.60	1.50	1.25	1.25	0.60	1.80	2.20	0.60
7.00	0.60	1.50	1.55	1.25	0.60	1.80	2.20	0.60
8.00	0.60	1.50	1.55	1.25	0.60	1.80	2.38	0.70
9.00	0.90	1.50	1.55	1.25	0.90	1.80	2.38	0.70
10.00	0.90	1.96	1.70	1.25	0.90	1.80	2.38	0.90
11.00	0.90	1.96	1.70	1.25	0.90	1.80	2.38	1.20
12.00	0.90	1.96	1.70	1.25	0.90	1.80	2.38	1.20
13.00-15.00	0.90	2.41	1.70	1.25	0.90	1.80	2.38	1.50
16.00	0.90	2.41	1.70	1.80	0.90	1.80	2.38	1.50
17.00-18.00	0.90	2.41	1.70	1.80	0.90	2.20	2.38	1.50
19	0.90	2.41	1.70	1.80	0.90	2.20	2.38	1.50
20	0.90	2.83	1.70	1.80	0.90	2.20	2.38	1.50
21	0.90	2.83	1.70	1.80	0.90	2.20	2.38	1.50
22	0.90	2.83	1.70	1.80	0.90	2.60	2.38	1.50
23	0.90	2.83	1.70	1.80	0.90	2.60	2.38	1.50

MB= Mould board, VCR= Vertical conveyer reaper
FMOS= Farm mechanization optimization software
Note: Soybean taken in *Kharif* and wheat in *Rabi*

In market only four sizes of disc harrow were available. The model selected the minimum size 5 x 5 discs harrow (1.25 m) for farm sizes up to 6 ha. The maximum size of the disc harrow i.e. 8 x 8 discs (1.7 m) was selected for farm sizes of 10 ha and above.

The model selected the minimum size SCFD i.e. 9 x 20 cm for farm sizes up to 16 ha. A 11 x 20 cm SCFD was selected for farm sizes of 17 to 21 ha, beyond which the maximum available size of 13 x 20 cm was selected. Since, the yield loss due to delay in sowing was high in comparison to tillage implements, the model tended to select higher size SCFD to complete the job in time.

The vertical conveyer reaper having 2.20 m and 2.38 m width size were available in the market. The minimum size of 2.20 m was selected for farm size upto 7 ha, whereas, beyond 7 ha the maximum size of 2.38 m reaper was selected by the model. Although there is option for hydraulic or non hydraulic type of the reaper in market. Due to additional cost of hydraulic type, the programme select the non hydraulic type for harvesting operation. This observation was in agreement with the opinion of the other researchers finding such as Baio *et al.* (2013).

Multi crop threshers were available in five different capacities ranging from 0.5 to 1.25 t/h. The model selected the minimum capacity thresher of 0.5 t/h for farm sizes up to 4 ha due to tractor power limitation. The next higher size (0.6 t/h) was selected for farm size of 5 to 7 ha. The model selected thresher of capacity 0.7 t/h for farm sizes of 8 to 9 ha and 0.9 t/h for farm sizes of 10 ha. The maximum available capacity thresher i.e. 1.25 t/h was selected for farm sizes more than 10 hectares.

4. Conclusion

The following conclusions can be drawn from the study.

1. Optimum tractor power requirement was found to increase linearly with farm size, whereas unit power requirement decreased initially with increase in farm size and thereafter, it became constant. The size of machinery was found to increase with the farm area.

2. The DSS helps in selection of a tractor or an implement of particular size from various makes and models of commercially available tractors and implements.

3. The validation of the DSS with a case study shows its effectiveness in predicting tractive performance of any virtual tractor implement system.

References:

Bio Fabio, H.R.,Rodrigues Andrew, D., Santosh Gilson, S., Dos, Silva Simona P.D.A.(2013). Mathematical to select mechanized agricultural systems by the lowest operational cost. *Journal of the Brasilian Association of Agricultural Engineering*.;**33(2)**:402-410.

Brown,W.J., Schoney, R.A. (2008). Calculating least-cost machinery size for grain farms using electronic spreadsheets and micronutrients. *Canadian Journal of Agricultural Engineering*,; **33(1)**: 47-65.

Camarena,E.A.,Gracia,C.,Sixto,J.M.C.(2004).A mixed integer linear programming machinery selection model for multi farm systems. *Bio System Engineering*, **87** 145-154.

Dash, R.C.,Sirohi,N.P.S.(2008).A computer model to select optimum size of farm power and machinery for paddy-wheat crop rotation in northern India. *Agricultural Engineering International, the CIGR E-journal*.Manuscript; **X (PM 08 012)**: 1-9.

Dubey,A.(2010). Decision support system for farm mechanization with the use of computer modeling for paddy-wheat crop rotation in Jabalpur district of Madhya Pradesh,Unpublished Ph. D. thesis, JNKVV, Jabalpur, India;.

Hetz, E.J., Esmay, M.L.(1986). Optimizatioon of machinery systems. Agricultural Mechanization in Asia. African and Latin America,**17(1)** : 68-76.

Isik, A., Sabanci, A. (1993) A computer model to select optimum size of farm machinery and power for mechanization planning. Agricultural Mechanization in Asia. Africa and Latin America,; **24(3)** : 68-72.

Naik,R.K.(2011.).Farm mechanization optimization and techno-economic solution with the use of computer modeling for paddy-chickpea crop rotation system in Chhattisgarh (India), Unpublished Ph.D thesis, JNKVV, Jabalpur, India;

Sahu, R.K, Raheman H.A. (2008).Decision support system on matching and field performance prediction of tractor–implement system. *Computer and Electronics in Agriculture,* **60**:76–86.

Sogaard, H.T., Sorensen,C.G.(2004).A model for optimal selection of machinery sizes within the farm machinery system. Biosystems Engineering, **89**(1):13-28.

Vatsa,D.K., Saraswat, D.C.(2008). Selection of power tiller and matching equipment using computer program for mechanizing hill agriculture. Agricultural Engineering International. *The CIGR E-journal manuscripts,*PM 07025(X).